Butler University Botanical Studies

Volume 5 *Butler University Botanical Studies* Article 13

Dendrometer studies on five species of broadleaf trees in Indiana

Ray C. Friesner
Butler University

Butler University Botanical Studies

(1929-1964)

Edited by

Ray C. Friesner

The *Butler University Botanical Studies* journal was published by the Botany Department of Butler University, Indianapolis, Indiana, from 1929 to 1964. The scientific journal featured original papers primarily on plant ecology, taxonomy, and microbiology. The papers contain valuable historical studies, especially floristic surveys that document Indiana's vegetation in past decades. Authors were Butler faculty, current and former master's degree students and undergraduates, and other Indiana botanists. The journal was started by Stanley Cain, noted conservation biologist, and edited through most of its years of production by Ray C. Friesner, Butler's first botanist and founder of the department in 1919. The journal was distributed to learned societies and libraries through exchange.

During the years of the journal's publication, the Butler University Botany Department had an active program of research and student training. 201 bachelor's degrees and 75 master's degrees in Botany were conferred during this period. Thirty-five of these graduates went on to earn doctorates at other institutions.

The Botany Department attracted many notable faculty members and students. Distinguished faculty, in addition to Cain and Friesner , included John E. Potzger, a forest ecologist and palynologist, Willard Nelson Clute, co-founder of the American Fern Society, Marion T. Hall, former director of the Morton Arboretum, C. Mervin Palmer, Rex Webster, and John Pelton. Some of the former undergraduate and master's students who made active contributions to the fields of botany and ecology include Dwight. W. Billings, Fay Kenoyer Daily, William A. Daily, Rexford Daudenmire, Francis Hueber, Frank McCormick, Scott McCoy, Robert Petty, Potzger, Helene Starcs, and Theodore Sperry. Cain, Daubenmire, Potzger, and Billings served as Presidents of the Ecological Society of America.

Requests for use of materials, especially figures and tables for use in ecology text books, from the *Butler University Botanical Studies* continue to be granted. For more information, visit www.butler.edu/

DENDROMETER STUDIES OF FIVE SPECIES OF BROADLEAF TREES IN INDIANA

By RAY C. FRIESNER

In a previous paper (2) results of a dendrometer and dendrograph study on *Fagus grandifolia* were given. The present paper presents results of an additional year of observations on the same species and a season of observations on four other species, viz. *Ulmus americana, U. fulva, Acer saccharum* and *Quercus alba.*

Observations on *Fagus grandifolia* extend throughout the calendar year 1941, those on *Ulmus fulva* began on April 14, and those on the other species began on March 3. In all cases observations included in the present discussion ended on December 22, 1941.

FAGUS GRANDIFOLIA

Previous studies on this species have been made by Dr. A. W. Gericke (5) and by the present writer (2). The former study was made during the season of 1919 on a tree near the Laboratory for Plant Physiology of Johns Hopkins University, Baltimore, Maryland, and the latter on three trees on the estate of Charles Lynn just north of Indianapolis.

In both studies growth changes were first noted coincident with the time of full expansion of the leaves, which in both instances was the middle of May. In the Baltimore tree growth continued until June 5 and showed intermittent growth, correlated with rains, until the latter part of September. In the Indianapolis trees diametral increase reached its maximum rate by the middle of June and continued with decreasing rate until the middle of July. From the last date until the end of the calendar year, decreases and increases alternated in correlation with rainless and rainy periods. At the close of the calendar year, one tree showed a net increase of 0.10 mm and the other a net increase of 0.082 mm over the radius at the time of cessation of increase in mid-July, thus indicating some growth activity subsequent to the time of ending of the main growth period.

Observations for the calendar year 1941 were limited to one tree (tree A of the 1940 period) which was 37.7 cm DBH. The diameter recorded by the dendrometer on December 30, 1940 was considered to be the zero point for the 1941 data. The period from this time

until the end of the first week in May. 1941 was occupied by alternate increases and decreases (table I). The first changes which can be interpreted as growth changes occurred during the week ending May 12. This is one week after the time of full expansion of the leaves and three weeks after the flowers were fully developed. Thus, while leaves reached full expansion two weeks earlier in 1941 than in 1940 the time of beginning of growth activity was but one week earlier. During both seasons, growth continued with increased intensity, the peak in rate being reached in 1940 during the week ending June 17 and in 1941 during the week ending June 2. Growth reached a zero point in 1940 during the week ending July 15 and in 1941 during the week ending June 16. The abrupt ending of radial changes in 1941 is correlated with drought conditions. Table II shows very definitely that the 1941 growing season began with a decided rainfall deficit which continued until after the June pause had set in. This probably accounts for the shorter period of radial increase during 1941 as compared to 1940. The period from beginning of radial increase to its primary cessation was 9 weeks in 1940 and 5 weeks in 1941. The 1940 growth period was entered following unusual rainfall in both April and May (167.13% and 110.54% of normal, respectively), whereas the 1941 growth period was entered following 6 months of subnormal rainfall (January through May being 56.94, 24.17, 28.49, 52.76 and 28.79% of normal, respectively: table II). Behavior after the June pause was one of almost continuous loss until late August and early September in spite of the fact that 193.92% of normal rainfall came in June. Apparently this was too late to halt the decreases already initiated before it came. The maximum length of the radius for the entire year was reached during the week ending September 2. This was a total increase of 0.78 mm over the radius at the beginning of the observation period on December 30, 1940. Behavior subsequent to the September maximum consisted of alternate decreases and increases, the radius showing a net loss of 0.06 mm on December 22 as compared to September 2. The total radial increase of this tree was 1.02 mm in 1940 and 0.78 mm in 1941 in spite of the fact that total rainfall for the year November to October was 63.13% of normal in 1940 and 78.25% of normal in 1941. It is thus apparent that total rainfall is not nearly so important in this regard as the time and manner in which it falls.

A dendrometer was attached to one tree measuring 35.3 cm in diameter on March 3, 1941. Flower buds began to swell during the week ending March 31 (table III). Flowers reached full size during the week ending April 7 and fruits were full size 2 weeks later, i. e. during the week ending April 21. Radial increase began during this same week though vegetative buds showed no appreciable activity until one week later, i. e. radial increase began during the week ending April 21 while vegetative buds began to swell during the week ending April 28. Maximum size of leaves was reached 3 weeks (week ending May 5) after initiation of radial increase and 2 weeks after vegetative buds began to swell. Radial increase continued at varying rates (table I) until the end of July after which losses and gains alternated but with a further net increase of 0.16 mm by the end of the first week in September.

In the work carried on by Dr. F. T. McLean (5) the observations began too late to show the correlation between initiation of radial increase and bud, fruit, and leaf activity above mentioned. In the present observations maximal rate of radial increase occurred during the week ending June 2 and a further and still higher peak in rate occurred during the week ending June 30. In the former observations (by McLean) the maximum rate apparently came at about the same time as the first maximum in the present observations but cessation of growth came 3 weeks later in the present work than in that of McLean.

The observations by Lodewick (3, 5) show that radial increase reaches a high rate of activity, spring wood formation has ceased and summer wood formation begun by the time the leaves reach full size; and cambial activity is about at an end by August 1. In the present paper radial increase came to a pause by the end of July but an increase during the week ending September 8 carried the total length of the radius 0.16 mm greater than it was at the time when growth came to the July-end pause.

Dendrographic data did not begin until June during the first 2 weeks of which the curve shows a steadily upward trend. Reversible variations were recorded for each day of this period but their magnitude was greatly reduced by the fact that this was the only period for the entire growing season when rainfall exceeded 53% of the normal-expected (table II), by the fact that evaporation rate was below that

for the periods before and after these 2 weeks (table I), and by the further fact that the hours of sunshine were much below normal, with rain falling on 9 of the 14 days. The maximum magnitude of these daily variations was 0.11 mm between peak and trough of the curves, the peak occurring between 6 and 8 in the morning and the trough between 5 and 6 in the afternoon. Subsequent weeks showed similar reversible variations differing only in degree until the first week in October after which the curves showed essentially straight lines. The curve for the week ending August 4, however, merits special mention. On July 29 the curve began dropping at 8 a. m. falling gradually for a loss of 0.15 mm until 2 p. m. when a further drop of 0.23 mm occurred so suddenly as to show a vertical line on the chart. A slight further loss between 2 p. m. and 6 p. m. brought the total loss for the day to 0.40 mm. During the night there was a recovery of 0.18 mm but the following day showed a further loss of 0.30 mm with 0.15 mm recovery the following night. Again, on August 2, the curve showed a gradual decline from 9 a. m. to 3 p. m. with 0.18 mm loss followed by a vertical drop shortly after 3 p. m. of 0.65 mm, making a total drop for the day of 0.83 mm. A recovery of 0.20 mm occurred during the night. There was thus a net loss of 1.00 mm shown by the dendrograph for this week. Dendrometers showed the following correlations for the same week: Fagus, 0.05 mm loss; *Ulmus americana,* 0.16 mm loss; *U. fulva,* 0.08 mm gain; *Acer saccharum,* 0.30 mm loss; and *Quercus alba,* 0.46 mm loss.

ULMUS FULVA

A dendrometer was attached to a tree 27.5 cm DBH. April 14, 1941 at which time the tree was in full flower. Radial increase apparently was just about to begin for an increase of 0.02 mm was recorded for the week ending April 21. Initiation of radial increase came one week before the fruits had reached full size though only a total of 0.06 mm had accumulated by this time. By comparison, *U. fulva* was one week later than *U. americana* in time of flower and fruit activity (table III) and, though the former began growth at the same time as the latter, its first 2 weeks of growth were much slower than the latter (table I). By the third week the two species were essentially equal in total growth increment and from that time on *U. fulva* was never surpassed in growth rate by *U. americana.* Peak in growth rate occurred during the week ending June 16 and gradually fell to zero during the week ending September 2; growth thus

covered a period of 19 weeks, 9 of which were occupied in rising to the peak and 10 in falling from the peak to the zero point. The period following the end of August was occupied by alternate losses and recoveries with the radius being 0.12 mm shorter on December 22 than on September 2. A maximum radial increase of 3.88 mm was recorded for the season. No previous published data on this species, secured by these methods, are known to the writer.

ACER SACCHARUM

A dendrometer was attached to a tree 22.5 cm DBH. March 3, 1941. Buds began to swell during the week ending April 14, flowers were fully developed one week later, and many leaves reached full expansion during the week ending May 5 (table III). Radial increase began during the week ending May 12 or one week after leaves had reached full expansion. In this regard Fagus and Acer were similar. These results are similar to those obtained by Dr. A. B. Stout on a tree in the New York Botanical Gardens as reported by MacDougal (5) in which radial increase was found to begin about the time when the earlier leaves reached full expansion. Rate of radial increase rose steadily for 4 weeks, dropped considerably for one week, and then rose again for 3 additional weeks to the highest peak in rate for the season during the week ending June 30 (table I). The rate then steadily declined until the end of July after which losses and recoveries alternated but with the final reading for the week ending December 22 showing a net loss of 0.84 mm as compared to the measurements at the time of cessation of growth.

QUERCUS ALBA

A dendrometer was attached to a tree measuring 21.9 cm DBH. on March 3, 1941. Buds began to swell during the week ending April 21 and leaves reached approximately full size during the week ending May 5 (table III). Radial expansion began during the week ending April 21, i. e. coincident with swelling of vegetative buds. In this regard *Quercus alba* was more like the two species of Ulmus than either Fagus or Acer. These results are similar in regard to correlation between bud activity and inception of radial activity to those found by MacDougal (5) in *Quercus kelloggii* and by Lodewick (3) in *Q. velutina* and *Q. borealis* var. *maxima.*

Following inception of radial increase further increases of varying weekly amounts are shown (table I) continuously until cessation

of growth during the week ending August 4. The peak in growth rate occurred during the week ending June 30. A total of 1.96 mm of radial increase was recorded before cessation.

DISCUSSION

From the foregoing it appears that the ring-porous trees in this study (Ulmus and Quercus) show a much earlier inception of growth in relation to vegetative bud activity than the diffuse-porous trees (Fagus and Acer.). The former show inception of cambial activity essentially coinciding with awakening of vegetative bud activity and the latter have cambial activity delayed until time when leaves have reached full size or nearly so.

From tables I and III it will be noted that Fagus shows a much shorter growing period than any of the others included in this study. Judging from the much shorter growth period shown by Fagus in 1941 than in 1940 and noting from table II that the 1941 season was less favorable than 1940 from the standpoint of rainfall during the time of growth it seems clear that this species shows a greater sensitivity to reduced soil moisture than the other species. Not until June did anywhere near normal amounts of rain fall and this did not come in time to stave off a shortening of the growth period for this species. Acer and both species of Ulmus showed effects of the rainfall-deficit by a falling-off of the growth rate in early June and a late June pick-up following the heavy June rainfall. Of course, it is obvious that other factors are involved in determining growth rate but some of these, such as evaporation rate, are apt to be high when rainfall is low thus creating a greater demand for water at the very time when it is least available. On the other hand, the number of hours of sunshine is likely to be greater when rainfall is less and this would permit more carbohydrates to be made for construction of cell materials, but, again, water is necessary to produce the turgidity upon which real expansion would depend.

The role of hormones in growth activity of trees is not well understood but as pointed out by MacDougal (4, 5) the cambium is aroused from its resting condition only by hormones generated in the buds or stem tips. In most cases initiation of cambial activity shows a definite relation to bud activity. In the present study, the ring-porous species show initiation of cambial activity essentially coincident with awakening of vegetative buds while the diffuse-porous species showed initiation of cambial activity about the time of full ex-

pansion of leaves. It is probable that in the latter species compounds produced only by the leaves, and after they are fully expanded or nearly so, are necessary for awakening of cambial activity.

These studies do not fully agree with MacDougal's statement (4, p. 237) that "once awakened, cambium illustrates a fundamental capacity to operate unceasingly without pause or rhythm and at a rate modified only by external conditions and food-supply." In Fagus, Acer, and both species of Ulmus the growth curves show definite acceleration in rate until a peak is reached and a corresponding deceleration until growth ceases. In the present study Acer and Ulmus show double peaks but in all four species a definite rhythm or grand-period type of curve is shown. External conditions without doubt, play important roles in determining the time of initiation, time of peak rate and time of cessation of growth and the amount of growth, but the growth rhythm occurs independently of definable rhythms in the external environment. They are most likely due to internal physiological conditions, such as available hormones, amount of diversion of hormones and other growth substances to other activities. The writer has shown (5) that daily rhythms in rate of root elongation are due to internal causes, such as alternation of times of maximum cell division and cell elongation.

SUMMARY

1. Radial and diametral changes have been studied with dendrometers and dendrograph on *Fagus grandifolia* (second season), *Ulmus americana, U. fulva, Acer saccharum* and *Quercus alba.*

2. Growth changes in Fagus and Acer were first noted near the time of full expansion of the leaves and in Ulmus and Quercus near the time of awakening of activity of vegetative buds. In the case of Ulmus this was near the time of full size of fruits.

3. Rate of expansion in Quercus showed a more irregular curve than in any of the other species. All others showed a curve approaching the grand-period type.

4. Fagus had a much shorter growing period than any of the other species. The period was: Fagus, 9 weeks in 1940 and 5 weeks in 1941; *U. americana,* 15 weeks; *U. fulva,* 19 weeks; Acer, 12 weeks; and Quercus, 15 weeks.

5. Fagus appears to show a greater sensitivity to soil moisture deficit than the other species studied.

6. Daily reversible variations occurred in *Ulmus americana* (the only species studied with the dendrograph during this season) showing the greatest diameter in the early forenoon and the shortest diameter in the late afternoon.

ACKNOWLEDGMENT

The writer is greatly indebted to Mr. John S. Wright for his interest and encouragement in this problem, to Mr. Charles F. Lynn for permission to use trees on his estate for study, and to Dr. D. T. MacDougal for his continued instructional aid.

LITERATURE CITED

1. Friesner, Ray C. Daily rhythms of cell division and elongation in certain roots. Amer. Jour. Bot. 7:380-407. 1920.
2. ———. A preliminary study of growth in the beech, *Fagus grandifolia*, by the dendrographic method. Butler Univ. Bot. Stud. 5:85-94. 1941.
3. Lodewick, J. E. Season activity of the cambium of some northeastern trees. Bull. New York St. Coll. For. 1(2a). 1921.
4. Mac Dougal, Daniel T. Studies in tree growth by the dendrographic method. Carnegie Inst. Washington Pub. 462. 1936.
5. ———. Tree growth. Chronica Botanica Company. 1938.

TABLE I

Weekly changes in radii of five species of trees together with meterological data.

Week ending	Radius changes										Meterological data		
	Fagus		U. americana		V. fulva		Acer		Quercus		Av. Mean Daily Temp.	Rainfall Inches	Av. Daily Evapor. Inches
	Current	Total	Current	Total	Current	Total	Current	Total	Current	Total			
1-6-41	−0.44	−0.44									−1.62°C	0.30	
1-13-41	0.34	−0.10									0.06	0	
1-20-41	−0.12	−0.22									0	0.76	
1-27-41	0.14	−0.08									0 29	0.62	
2-3-41	0.02	− .06									0.29	0	
2-10-41	−0.10	−0.16									−2.40	0.12	
2-17-41	0.12	−0.04									2.22	0.47	
2-24-41	−0.14	−0.18									−6.77	0	
3-3-41	0.14	−0.04									−0.40	0.19	
3-10-41	0	−0.04	0	0			0	0	0	0	1.18	0.30	
3-17-41	−0.20	−0.24	−0.10	−0.10			−0.20	−0.20	−0.36	−0.36	−0.40	0.12	
3-24-41	0.20	−0.04	0.28	0.18			0 16	−0.04	0.36	0	3.78	0.11	
3-31-41	0	−0.04	−0.02	0.16			0	−0.04	−0.02	−0.02	4.84	0.47	
4-7-41	0	−0.04	−0.16	0.			−0.02	−0.06	−0.12	−0.14	9.48	0.60	0.095
4-14-41	−0.12	−0.16	−0.06	−0.06			0	−0.06	0.06	−0.12	17.81	0.01	0.152
4-21-41	0.03	−0.13	0.22	0.16	0.02	0.02	0.02	−0.04	0.18	0.06	18.47	1.30	0.189
4-28-41	−0.03	−0.16	0.04	0.20	0.04	0.06	0	−0.04	0.06	0.12	11.48	0	0.153
5-5-41	0	−0.16	0 10	0.30	0.28	0.34	0.04	0	0.12	0.24	20.03	0	0.196
5-12-41	0.13	−0 03	0.02	0.32	0.12	0.46	0.20	0.20	0.06	0.30	13.37	0.68	0.126
5-19-41	0.08	0.05	0.16	0.48	0.04	0.50	0.32	0.52	0.06	0.36	17.25	0.21	0.175
5-26-41	0.15	0.20	0.08	0.56	0.12	0.62	0.40	0 92	0.04	0.40	22.25	0.02	0.295
6-2-41	0.22	0.42	0.38	0.94	0.42	1.04	0.46	1.38	0.20	0.60	25.98	3.26	0.275

TABLE I—(Continued)

Week ending	Radius changes										Meterological data		
	Fagus		U. americana		U. fulva		Acer		Quercus		Av. Mean Daily Temp.	Rainfall Inches	Av. Daily Evapor. Inches
	Current	Total	Current	Total	Current	Total	Current	Total	Current	Total			
6-9-41	0.14	0.56	0.06	1.00	0.42	1.46	0.12	1.50	0.23	0.83	22.75	1.34	0.200
6-16-41	0	0.56	0.16	1.16	0.44	1.90	0.22	1.72	0.21	1.04	19.25	2.26	0.117
6-23-41	0	0.56	0.08	1.24	0.28	2.18	0.42	2.14	0.16	1.20	25.13	0.28	0.202
6-30-41	0	0.56	0.46	1.70	0.40	2.58	0.56	2.70	0.42	1.62	27.63	0.10	0.241
7-7-41	–0.04	0.52	0.10	1.80	0.28	2.86	0.51	3.21	0.12	1.74	24.47	0.24	0.243
7-14-41	0.04	0.56	0.10	1.90	0.37	3.23	0.37	3.58	0.07	1.81	23.47	0.23	0.226
7-21-41	0.04	0.60	0.07	1.97	0.27	3.50	0.28	3.86	0.03	1.84	22.47	0.39	0.246
7-28-41	–0.10	0.50	0.21	2.18	0.20	3.70	0.16	4.02	0.12	1.96	29.24	0	0.261
8-4-41	–0.05	0.45	–0.16	2.02	0.08	3.78	–0.30	3.72	–0.46	1.50	28.46	0.35	0.324
8-11-41	–0.13	0.32	–0.04	1.98	0.04	3.82	–0.10	3.62	–0.06	1.44	27.75	0.06	0.266
8-18-41	0.27	0.59	0.06	2.04	0.04	3.86	–0.06	3.56	0.04	1.48	22.20	0.96	0.231
8-26-41	0.12	0.71	0.04	2.08	0.02	3.88	0.02	3.58	0.08	1.56	23.25	0.38	0.178
9-2-41	0.07	0.78	–0.04	2.04	0	3.88	0.02	3.60	0.04	1.60	24.42	0.84	0.211
9-8-41	–0.10	0.68	0.30	2.34	–0.06	3.82	–0.06	3.54	–0.10	1.50	24.69	0.51	0.138
9-15-41	–0.06	0.62	–0.12	2.22	–0.02	3.80	–0.08	3.46	–0.10	1.40	20.75	0.32	0.212
9-22-41	–0.10	0.52	–0.08	2.14	–0.06	3.74	–0.02	3.44	–0.08	1.32	21.64	0	0.198
9-29-41	–0.32	0.20	0.16	2.30	0.06	3.80	0.02	3.46	–0.24	1.08	18.87	0.18	0.161
10-6-41	0.42	0.62	0.08	2.38	0.06	3.86	–0.04	3.42	0.44	1.52	20.00	3.46	
10-13-41	0.02	0.64	–0.08	2.30	0	3.86	–0.16	3.26	–0.12	1.40	15.76	0.62	
10-20-41	0.03	0.67	0	2.30	0.02	3.88	0.02	3.28	0.04	1.44	16.31	1.17	
10-27-41	0.03	0.70	0	2.30	0	3.88	0.02	3.30	0.06	1.50	13.54	0.52	
11-3-41	0.01	0.71	0	2.30	0	3.88	–0.08	3.22	–0.06	1.44	9.70	1.53	
11-10-41	0.03	0.74	–0.04	2.26	0	3.88	0.04	3.26	0.06	1.50	4.51	1.10	
11-17-41	–0.02	0.72	–0.10	2.16	–0.02	3.86	–0.04	3.22	–0.08	1.42	8.59	0	

TABLE I—(Continued)

Week ending	Radius changes										Meterological data		
	Fagus		U. americana		U. fulva		Acer		Quercus		Av. Mean Daily Temp.	Rainfall Inches	Av. Daily Evapor. Inches
	Current	Total	Current	Total	Current	Total	Current	Total	Current	Total			
11-24-41	0.02	0.74	–0.02	2.14	–0.08	3.78	0	3.22	0.06	1.48	7.05	1.10	
12-1-41	0	0.74	0	2.14	0.04	3.82	0.02	3.24	–0.04	1.44	8.93	0	
12-8-41	0	0.74	0	2.14	–0.02	3.80	–0.02	3.22	0	1.44			
12-15-41	–0.10	0.64	0	2.14	–0.08	3.72	–0.04	3.18	0	1.44			
12-22-41	0.08	0.72	–0.04	2.10	0.04	3.76	0	3.18	0	1.44			

TABLE II

Rainfall in relation to normal. Seasons 1939-1941

Month		Rainfall	Normal-expected	Percentage of Normal
November	1939	1.15 inches	3.35 inches	34.32%
December	1939	1.13	2.98	37.92
January	1940	1.38	2.95	46.77
February	1940	2.38	2.73	87.18
March	1940	0.90	3.93	22.90
April	1940	6.05	3.62	167.13
May	1940	4.30	3.89	110.54
June	1940	1.88	3.62	51.93
July	1940	0.90	3.34	26.94
August	1940	2.91	3.31	87.91
September	1940	1.06	3.40	31.17
October	1940	1.15	2.78	41.36
Total	1939-40	25.19	39.90	63.13
November	1940	3.38	3.35	100.89
December	1940	2.58	2.98	86.57
January	1941	1.68	2.95	56.94
February	1941	0.66	2.73	24.17
March	1941	1.12	3.93	28.49
April	1941	1.91	3.62	52.76
May	1941	1.12	3.89	28.79
June	1941	7.03	3.62	193.92
July	1941	1.21	3.34	36.23
August	1941	1.40	3.31	42.30
September	1941	1.94	3.40	57.06
October	1941	7.19	2.78	258.64
Total	1940-41	31.22	39.90	78.25
May-Oct.	1940	12.20	20.34	59.98
May-Oct.	1941	19.89	20.34	97.79
May-Sept.	1941	12.70	17.56	72.32
Nov.-Apr.	1940	12.99	19.56	66.41
Nov.-Apr.	1941	11.33	19.56	57.92

TABLE III

Correlation of growth changes with other activities of the trees.

Activities	Fagus 1940	Fagus 1941	Ulmus americana	Ulmus fulva	Acer	Quercus
DBH. at beginning of period —cm.	37.5	37.7	35.3	27.5	22.5	21.9
Flower buds begin to swell		4–21	3–31	4–7		none
In full flower		4–21	4–7	4–14	4–21	none
Vegetative buds begin to swell		4–21	4–28	4–28	4–14	4–21

TABLE III—(Continued)

Activities	Fagus 1940	Fagus 1941	Ulmus americana	Ulmus fulva	Acer	Quercus
Fruits full size			4–21	4–28		none
Leaves full size	5–20	5–5	5–12	5–19	5–5	5–12
Radial enlargement begins	5–20	5–12	4–21	4–21	5–12	4–21
Radial enlargement reaches primary peak	6–17	6–2	6–2 6–30	6–16	6–30	6–30
Primary pause in radial enlargement	7–15	6–16	8–4	9–2	8–4	8–4
All radial growth-enlargement ceased	7–15	9–8	9–8	9–2	8–4	8–4
Increase during 1941—mm.	1.02	0.72	2.38	3.88	4.02	1.86
Interval between beginning and ending of growth —weeks	9	5	15	19	12	15